PB84-168699

Mapping Sunken Pollutant Pools with Depth Finders

Rockwell International, Newbury Park, CA

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

1984

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-168699

EPA-600/D-84-076
1984

MAPPING SUNKEN POLLUTANT POOLS WITH DEPTH FINDERS

by

Raymond A. Meyer
Rockwell International
Newbury Park, CA 91320

John E. Brugger
U.S. Environmental Protection Agency
Edison, NJ 08837

and

Darrell J. Lowrance
Lowrance Electronics, Inc.

Contract Number 68-03-3014

Project Officer

John E. Brugger
Oil and Hazardous Materials Spills Branch
Solid and Hazardous Waste Research Division
Municipal Environmental Research Laboratory (Cincinnati)
Edison, New Jersey 08837

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/D-84-076	2.
3. RECIPIENT'S ACCESSION NO. PB84 166699	
4. TITLE AND SUBTITLE Mapping Sunken Pollutant Pools With Depth Finders	5. REPORT DATE 1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Raymond A. Meyer and John E. Brugger	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rockwell International 2421 West Hillcrest Drive Newbury Park, CA 91320	10. PROGRAM ELEMENT NO. CBRD1A
	11. CONTRACT/GRANT NO. 68-03-3014
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268	13. TYPE OF REPORT AND PERIOD COVERED Paper
	14. SPONSORING AGENCY CODE EPA/600/14
15. SUPPLEMENTARY NOTES Project Officer: John Brugger (201) 321-6634	

16. ABSTRACT

Many hazardous substances and mixtures are immiscible with and more dense than water. When spillages or releases into waterbodies occur, the hazardous materials will disperse in a pattern controlled by physical properties of the material, flow and dispersion effects, and topography of the waterbody bed. Mapping (i.e., location and thickness determination) of the spilled substance is essential for prompt and economical removal to protect biota and ensure minimal contamination of water. Analysis of the reflection patterns of acoustic waves (ca. 200 kHz) beamed into the water from a boat is shown in this and in previous work to serve as an excellent mapping technique. To properly plot pollutant pool location and depth, the coordinates of the boat position must also be determined. As the acoustic pulse passes through the water, pollutant, and sediment, reflected waves are generated at each interface (water/pollutant; pollutant/sediment). Depth (thickness) is computed from acoustical parameters and from the times between the transmission of the pulse and the detection of the reflected pulses (echoes). The depth and precision of detection is ultimately limited by the attenuation and dispersion of the echoes. By placing the transmitter/detector element at known depths below the boat, detection depth is almost unlimited and the detectable thickness of the pollutant can be as small as 1 cm.

When the project to map pollutants was initiated, no suitable commercial devices were available. A very effective, portable, battery-operated prototype system was constructed. The reflection data (intensity vs time) were displayed on an on-board dual-trace oscilloscope that had time-delay features. Subsequently, a suitable commercial system was test marketed and has been successfully used in the field to locate creosote in a waterbody. Readout is on chart paper. The instrument is operated from a boat, which follows a scanning pattern at speeds up to 8 km/hr (5 mph) for gross evaluation and at much slower speeds for accurate measurements. Once a pool is located, the position can be confirmed by recording the readings from a conductivity meter as the sensor is lowered into (or raised from) the water body. Actual samples of the pollutant can be acquired by standard techniques.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 24
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

HMS Conference Paper # 140

MAPPING SUNKEN POLLUTANT POOLS WITH DEPTH FINDERS[1]

Raymond A. Meyer

Rockwell International

Newbury Park, CA 91320

John E. Brugger

U.S. Environmental Protection Agency

Edison, NJ 08837

and

Darrell J. Lowrance

Lowrance Electronics Inc.

Tulsa, OK 74128

ABSTRACT

Many hazardous substances and mixtures are immiscible with and more dense than water. When spillages or releases into waterbodies occur, the hazardous materials will disperse in a pattern controlled by physical properties of the material, flow and dispersion effects, and topography of the waterbody bed. Mapping (i.e., location and thickness determination) of the spilled substance is essential for prompt and economical removal to protect biota and ensure minimal contamination of water. Analysis of the reflection patterns of acoustic waves (ca. 200 kHz) beamed into the water from a boat is shown in

---

[1]The work reported in this paper was funded chiefly by the United States Environmental Protection Agency under Contract No. 68-03-3014 with Rockwell International. It has been subject to the Agency's peer and administrative review and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

this and in previous work to serve as an excellent mapping technique. To properly plot pollutant pool location and depth, the coordinates of the boat position must also be determined. As the acoustic pulse passes through the water, pollutant, and sediment, reflected waves are generated at each interface (water/pollutant; pollutant/sediment). Depth (thickness) is computed from acoustical parameters and from the times between the transmission of the pulse and the detection of the reflected pulses (echoes). The depth and precision of detection is ultimately limited by the attenuation and dispersion of the echoes. By placing the transmitter/detector element at known depths below the boat, detection depth is almost unlimited. The detectable thickness of the pollutant can be as small as 1 cm.

When the project to map pollutants was initiated, no suitable commercial devices were available. A very effective, portable, battery-operated prototype system was constructed. The reflection data (intensity vs time) were displayed on an on-board dual-trace oscilloscope that had time-delay features. Subsequently, a suitable commercial system was marketed and has been successfully used in the field to locate creosote in a waterbody. Readout is on chart paper. The instrument is operated from a boat, which follows a scanning pattern at speeds up to 5 mph (8 km/hr) for gross evaluation and at much slower speeds for accurate measurements. Once a pool is located, the position can be confirmed by recording the readings from a conductivity meter as the sensor is lowered or raised within the water body. Actual samples of the pollutant can be acquired by standard techniques.

INTRODUCTION

Spills or releases of hazardous liquids into rivers, streams, or lakes cause severe environmental impact that can result in massive fish kills or contamination of municipal water supplies. Many hazardous materials are

immiscible with and denser than water. These insoluble sinking pollutants should be promptly detected and mapped so that cleanup operations can be initiated to minimize health and environmental impacts. Pollutants of this class will sink rapidly to the bottom and form localized pools or, when turbulence is great enough, the pollutant will remain suspended in the water column until the contaminant reaches a quiescent area of the watercourse where it will settle out. Very often, the nature and existence of the spill movement of the pollutant pools is necessary to direct cleanup operations and to avoid widespread environmental damage.

Each incident presents new and different challenges. This document must be viewed as a guide, subject to major or minor changes dictated by the spill environment. The technique has been carefully tested under laboratory conditions and has undergone extensive field testing in uncontaminated waters. Additional testing was conducted at the U.S. EPA-ORD Oil and Hazardous Materials Simulated Test Tank (OHMSETT) at Leonardo, NJ. One of the authors (Raymond A. Meyer) used the system in actual incidents, which will be referred to as the "EDC Spill" and "The Creosote Pond".

DEVELOPMENT HISTORY

When the project was initiated, commercial depth-finders were evaluated to ascertain their applicability to the problem. The available systems did not have the spatial resolution required. Accordingly, a development program was pursued leading to the construction of a successful, oscilloscope-based system.(2) A major breakthrough was the development of a monopulse generator

---

(2) "Detection and Mapping of Insoluble Sinking Pollutants", Meyer, R.A., et al., EPA-600/2-81-198, Oct. 1981, available from NTIS as PB-82-104-586. A summary may be obtained from the U.S. EPA Center for Environmental Research, Cincinnati, OH 45268. The work was performed as Task 10 of EPA Contract 68-03-2648 by Rockwell International, Newbury Park, CA 91320.

that produced a single, sharp transmit pulse. A dual-trace oscilloscope, with sweep delay, was used to amplify and clearly identify the return echo. One patent has been awarded and two are pending as a result of this work. This system uses a modification of the depth-finder or echo-sounder principle. It projects a single short pulse of ultrasonic energy (200 kHz) toward the bottom and permits the detailed study of the return echo. The bottom echo is usually a complex series of echoes from various sub-bottom strata. However, both laboratory studies and field work show that a significant portion of the energy is reflected from the surface of the pollutant pool. This results in an echo that is a precursor to the bottom echo. It is separated from the bottom echo by the time it takes the sound to pass through the pool to the bottom and return to the surface of the pool. Since the speed of sound in the pollutant is either already known or can be determined with the system, the measured time between the two echoes may be used to determine the pool depth at that point. In the system, the return echoes are amplified up to 2500 times and displayed on the oscilloscope for video photography and operator study. Pollutant layers 1-cm thick can be resolved. The time base of the echo display is magnified through use of the scope's delay sweep feature. The system includes an auxiliary depth-finder with 0.1-ft (3-cm) resolution and a digital display along the side of the scope screen. A video camera and tape recorder continuously record the scope and depth-finder images.

Micro-navigational data are recorded in audio form on the video tape. Thus, the boat's path can be plotted along with the operator's evaluation of the echo signals, resulting in a map of the pools' locations. Suspected pools are confirmed by an electrical conductivity measurement.

USE OF THE PROTOTYPE SYSTEM AT AN EDC SPILL

In late September, 1981 a nominal 350,000 gal (1.3×10^6 L) of EDC

(ethylene dichloride, 1,2-dichloroethane) were lost into Lake Ferguson near Greenville, Mississippi. Lake Ferguson is an ox-bow of the Mississippi River that is sealed at the upstream end. At the point of the spill, the lake was 700 ft (200 m) wide with the river at a low level. The bottom sloped gradually from the Ergon Dock, the spill site, to a sharply dredged 35-ft (10-m) deep channel. Depth soundings are shown in Figures 1 and 2. The very fortuitous existence of a bottom ledge confined the EDC pool at its downstream end. (Upstream and downstream are used as directional indicators only since there was little, if any, water flow.) EPA Region IV and Mississippi State personnel had been on scene for several days before Rockwell was asked to respond. They (region and state) had located the spill pool using both an electrical conductivity meter and a pumping technique. Within a few minutes at the site, the ultrasonic oscilloscope system confirmed the existence of the pool. This was the first actual use of the system, which was still in breadboard form. However, it proved to be an extremely useful field test and much knowledge was gained during the response. This particular spill was not a challenge for the system since the pool was localized in one body about 360 ft x 120 ft x 2-3 ft deep (100 x 35 x 0.7-1.0 m). Deployment limitations precluded the use of the ultrasonic system to search for satellite pools. Cleanup was accomplished with a pump barge and a nominal 300,000 gal (1.1×10^6 L) of EDC were recovered.

While the final report on the oscilloscope system was being completed, Lowrance Electronics of Tulsa, Oklahoma, placed the X-15 graph recorder on the market. This small, commercial unit represented a major advance in the technology of readily available depth finders.

THE LOWRANCE X-15 SYSTEM

The 7-lb (3.5-kg) unit is microprocessor-controlled and, although many

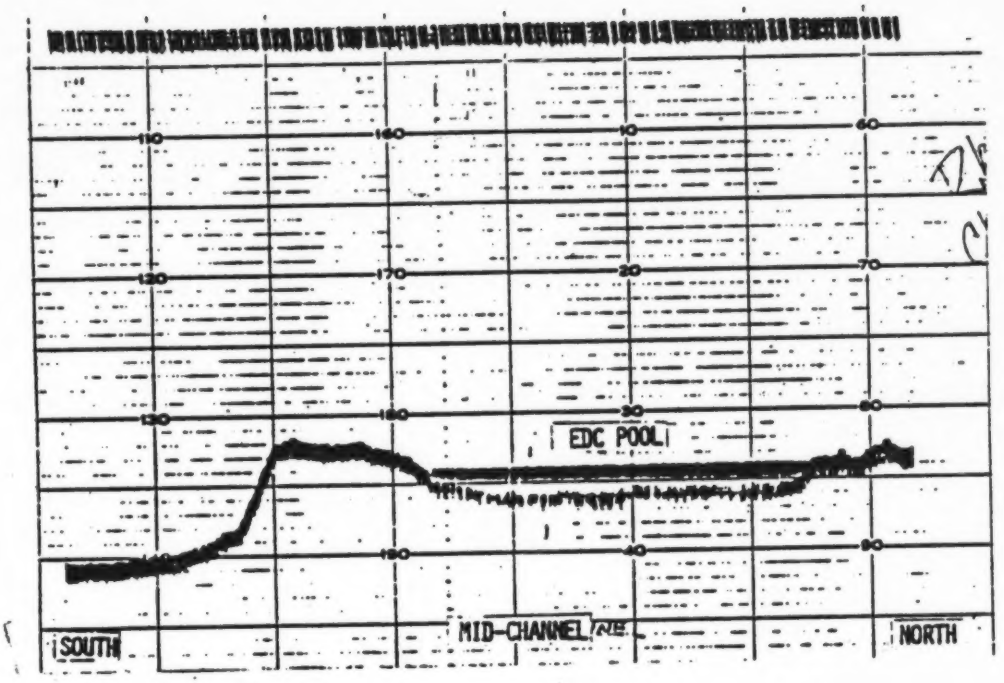


Figure 1. South-North Sweep at EDC Spill

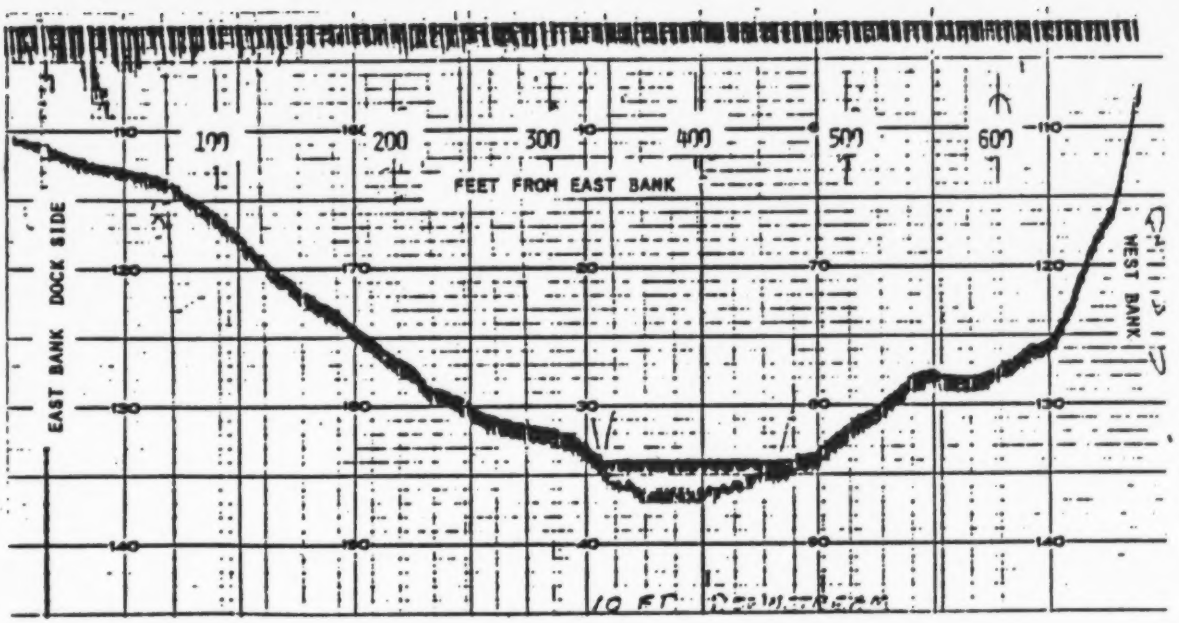


Figure 2. East-West Sweep at EDC Spill.

parameters are set automatically according to the depth range, the operator has wide over-ride privileges. It has a peak-to-peak transmit power of 1600 watts. Usable signals have been received in water 1000-ft (300-m) deep. It operates from a 10.5 to 15 volt D.C. source (such as an automobile battery) and requires 1.2 amps.

When the unit is turned on, an electronically regulated motor drives the recording paper. A marking stylus is provided. The recording paper is so treated that electric current flow between the stylus and a backing plate will create a permanent mark. The mark density is a function of the current. The X-15 has 3 signal levels: off (white), grey, and black. The microprocessor produces electrical pulses at the proper intervals to generate scale lines, depth numbers, and parameter values and to record the arrival of echoes from the bottom and intervening objects such as fish, weeds, and pollution pools.

Every 105 milliseconds (ms), the transducer is energized for the length of time established by the pulse width. The pulse repetition rate is a function of the depth range. A pulse of 192 kHz ultrasonic energy passes through the water body and reflects echoes from intervening objects until the attenuated pulse reaches the bottom and is then reflected as the bottom echo. The time between the initiation of the pulse and the return of the echo at the transducer governs the position of the grey or black mark on the chart. The several adjustable parameters and their optimization for pool locating and mapping will be discussed individually.

Pulse Width

The pulse width is the length of time the transducer is energized. While it is automatically selected based on the depth range, it can be operator-defined over a range of 30 to 2000 μs (microseconds). In this usage of the

X-15, depth resolution is defined as the depth of the pool required to generate separable echoes. It is directly proportional to the pulse width and a 30-μs pulse provides 1-in. (2.5-cm) resolution. Unfortunately, total transmittal energy is also a function of pulse width and the 30-μs pulse is recommended only for depths up to 100 ft (30 m). Beyond this depth or in very turbid water, resolution may have to be sacrificed because of signal limitations.

Range

Using the keyboard range selection, the X-15 can be set to display any 10-ft (3.3-m) or greater segment between depth ranges of 0-10 ft and 0-2490 ft (1 m = 3.3 ft). The upper and lower limits are set independently. Chart resolution is a function of the distance between the upper and lower limit. When the range displayed is 10 ft (say, upper level = 90 ft and lower level = 100 ft), a 1-in. (2.5-cm) deep pool displays 2 echoes 0.03 in. (1 mm) apart on the chart. High resolution is accompanied by an undesirable sensitivity to depth changes such that the bottom echo can move rapidly off the graph. Thus, for survey work where the boat is moving 3 to 4 miles per hour (5-6 km/hr), the range may have to be widened to accomodate the depth changes. When the low point of the bottom contour is located, the boat speed should be greatly reduced and the range set to 10 ft (3.3 m).

Greyline Control

The X-15 has a control that allows the operator to display strong signals as grey rather than black. This feature allows display of the bottom echo as a thin black line over a grey segment. This adjustment facilitates the separation of a pollutant pool echo from the bottom echo.

Paper Speed

The position of this control must be selected according to the spatial

resolution required. The balance is between running out of paper and enhancing resolution. Table 1 shows nominal paper-speed values. The allowable boat speed is determined by the chart speed and the desired linear chart resolution. For example, a boat speed of 2 mph (3 km/hr) will result in a 50 ft/chart-inch (5 m/chart-cm) resolution at the maximum available chart speed of 3.27 in./min (8 cm/min).

TABLE 1. AUTOMATIC PAPER SPEEDS

Lower Limit	Max Speed (mm/min)	Hr/Roll	Min Speed (mm/min)	Hr/Roll
10-120 feet	83.0	3.2	2.6	10.0
130-510 feet	51.5	5.1	4.75	17.7
520-830 feet	26.8	9.8	7.2	36.3

Suppression

The suppression control reduces interference from short-duration pulse noise such as ignition and cavitation. Suppression increases the transmit pulse width and therefore decreases depth resolution.

Marker

When the keyboard button labelled "mark" is pressed, the unit continuously prints a vertical line as long as the key is depressed. This function is used to mark the chart to correspond to statements in the search log.

DEPLOYMENT CONSIDERATIONS

Boat

The depth-finder, such as the Rockwell system or the X-15, will typically be deployed from a rented boat. There are several parameters that should be considered when selecting the boat:

1. Slow speed capability: The search speeds will range from a few feet per minute to a maximum of 5 mph (8 km/hr). The recommended charting speed is in the 2 mph (3 km/hr) range. The use of trolling plates should be considered to reduce boat speed.

2. Freeboard: When the transducer is deployed outboard using a special bracket, the distance from the boat deck to the water must be limited to 2 ft (60 cm) or an alternate mounting clamp must be devised.

3. Comfort: While operator comfort may not appear to be a major factor, consider that the operators will spend many hours in the boat and prolonged attentiveness is required.

4. Boat weight: A light weight boat provides an unstable platform for system deployment. When one is forced to use such a boat, ballast (such as rocks) may help stabilize the craft, provided that the boat is not overloaded to the detriment of safety.

Batteries

The Rockwell and X-15 systems are designed to run from a 12 VDC battery. Advance personnel should purchase and fully charge a new, deep-cycle, 12-volt Marine-R/V battery of nominal 85 amp-hour rating. The battery should be recharged each night. These requirements are based on an 8-to-10-hour workday. Since the entire response effort is based on the battery, it is very poor economy to use old, used, or questionable batteries. Because of possible electronic damage caused by over-voltage spikes, operation from power supplies is not recommended. The use of the boat battery can be a source of electronic noise.

Buoys

Watercourse traffic sometimes permits the use of buoys to mark suspect or proven pool locations. At the EDC spill, heavy barge traffic destroyed most of the buoys each day. Gallon plastic milk jugs, 1/8-in.(3-mm) diameter nylon line, and common brick were combined to make good buoys. The relation of the length of the buoy cord to the water depth must be considered with care since slack line allows the buoy to wander over a surprisingly large radius.

Personnel

Either system can be operated by one very busy person, but this approach is not recommended. The following tasks must be accomplished, and a staff of four is suggested.

1. Depth-finder operator: The leader of the operation monitors the depth-finder record and directs the boat operator and conductivity meter operator. He annotates the recorder chart with navigational data and dictates comments to the recordkeeper.

2. Boat operator: This person maneuvers the boat according to the requests of the operations leader and the navigator-conductivity meter operator. The boat operator should be skilled in operating a small boat at very slow speeds.

3. Navigator/conductivity-meter operator: This inidivdual is responsible for directing the boat path according to the pre-planned search pattern. He must be alert to the effects of wind and current and must instruct the boat operator accordingly. As requested by the search leader, he deploys the conductivity meter to verify pool location.

4. Recordkeeper/buoy deployer: This operator maintains a written log. He supplies the leader with a series of successive numbers for annotating the recorder chart. The numbers are used to relate chart data to written log sections. He records the comments of the leader and relates them to time and boat location. He also deploys the buoys and records their location and significance.

Navigational sites

Suitable sites or survey lines for shore-based navigation should be established prior to the arrival of the team. The requirements are discussed later in the section on search and mapping.

ON-SITE DEPLOYMENT

Conductivity Probe

Typical watercourse electrical conductivities are over 500 micromhos/cm while the pollutants of interest have conductivities of less than 1 micromho/cm. Thus, when the probe enters the pool, the meter reading drops to zero. Such a wide difference in conductivity eliminates any need to maintain meter calibration. In use, the search leader halts boat movement when a suspect area is located and the area is tested by lowering the conductivity probe to the bottom. When a very low or zero reading is noted, the area is marked for pollutant recovery. The approximate depth of the pool can be measured by slowly raising and lowering the probe. The probe is heavy enough that its arrival at the bottom is clearly evident to the operator. Electrical conductivity measured pool depths correlated well with ultrasonic measurements at the EDC spill.

Transducer

The X-15 transducer is the 9-cm-long, boat-shaped, black plastic unit on the end of the long cable; and the Rockwell unit is similar. Although only general suggestions can be given, one factor is definite: the transducer must be aimed straight down when the boat is in operation and personnel are in position. The attitude of a small boat in the water is very dependent on both the speed of the boat and location of the operating personnel. These factors must be taken into consideration when mounting the transducer. The transducer position for the X-15 is optimized by setting the depth range at 3 times the water depth, advancing the "sensitivity" control until a second echo is seen below the real bottom echo and adjusting the position and orientation of the transducer for the strongest signals. This operation may be most easily understood by considering the transducer's ultrasonic beam action in terms of the behavior of a beam of light. Secondary echoes result from multiple reflections of the primary echo wave between the water surface and the bottom. Part of each reflection is detected by the transducer. During testing in a 55-gal (200-L) drum, 17 clean echoes were resolved.

Instrument Cabinet

The unit should be placed near eye level of the seated operator. Remember that he will be looking at it for several hours and annotating the chart.

Pool Verification

Changes in the echo pattern must not be considered as proof of pool location. While the presence of a stable echo above the bottom echo is a good indication, the existence of the pool must be verified by electrical conductivity measurements. At the EDC spill, suspended mud on the pool surface returned echoes similar to those form the EDC. The conductivity meter indicated a high conductivity in the mud layer followed by zero conductivity when the probe entered the EDC.

SEARCH AND MAPPING

Each operation will be quite unique since it depends upon the configuration of the water body. Only general suggestions can be given to guide the operator in the search.

The typical path of dense, immiscible liquids entering a waterbody follows the line of maximum downward slope until travel is stopped by an upward slope, whereupon the material gathers into a pool. This pool fills until the pool surface tops the upward slope and then the material overflows to resume its travel to fill the area of maximum depth or until the source of the spillage is depleted. The deposition path can form a series of pools stair-stepping along the bottom of the watercourse: one large pool on the bottom of the channel, a long narrow ribbon, etc. The easiest way to visualize the pollutant path is to remember the appearance of watercourses or lakes as the water level is lowered. The waterbody decreases in width and length and eventually separates into individual pools. The pollutant liquid under the water will assume the same position as that of the last water to evaporate.

It is the task of the operator to locate these pools and direct their removal. Detailed bottom topographic maps are seldom available since normal users are not concerned with 6-in.(15-cm) changes in depth. Six-inch depths do have meaning in spill mapping when one considers that a pool 20-ft long and 10-ft wide (6-m x 3-m) contains 780 gallons (3000 L) even when it is only 6 in. deep.

It is recommended that the operator first make a series of runs along the shore where the material entered the water. A study of the chart records will reveal the general pattern of the bottom topography. This record should provide sufficent information to guide successive sweeps along the line of increasing depth until the pool or pools are located. The operator must

consider the possible existence of secondary pools that stair-step below the first one located. Once a pool is located and marked with a buoy, the actual mapping phase of the program is initiated.

The acutal mapping of a pool requires some form of micro-navigation to establish the true dimension of the pool and to precisely locate it for recovery. Many techniques have been considered and rejected for one reason or another. Loran and sattelite systems are slow and lack precision; short range radio beacon systems are costly and require skill in deployment; and the laser transit approach used at the EDC spill proved unsatisfactory since the operator was unable to "hit" the reflector on the moving boat with the laser beam. Other ideas such as placing a series of poles on shore and operating the boat to keep pairs of poles aligned did not provide the desired resolution.

A dual theodolite technique shows the most promise of success. The theodolite operators read their instruments in a time-sychronized pattern and the elevation and azimuth readings are used to determine the track and speed of the boat. Application of this technique to mapping pollutant pools requires two transits or theodolites and radio or other signal contact between the two operators and the boat. The depth-finder operator assigns a navigation number to a mark on the chart and each transit operator records the instrument readings at that time. The three series of data are correlated at the end of the day to generate a map of the pool.

Lowrance Electonics publishes a booklet titled "In Time of Need," which describes the use of their instruments in searching for drowing victims and underwater objects. The techniques decribed are equally useful in locating pollutant pools. Figures 3 and 4 are reproductions of charts supplied by John Will, Illinois Dept. of Conservation. These illustrate the use of the X-15 in

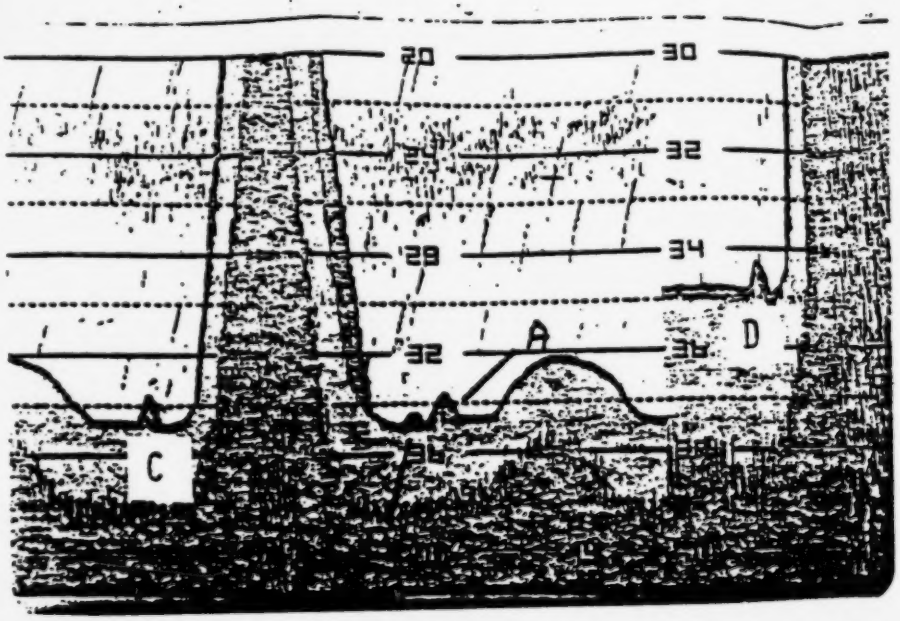


Figure 3. X-15 Graph Example.

Left--depth range 20 to 40 ft-- A=barrel; B=drowning victim; C=unidentified object.

Right--depth range 30 to 40 ft-- D=unidentified object (same as C but at twice the resolution).

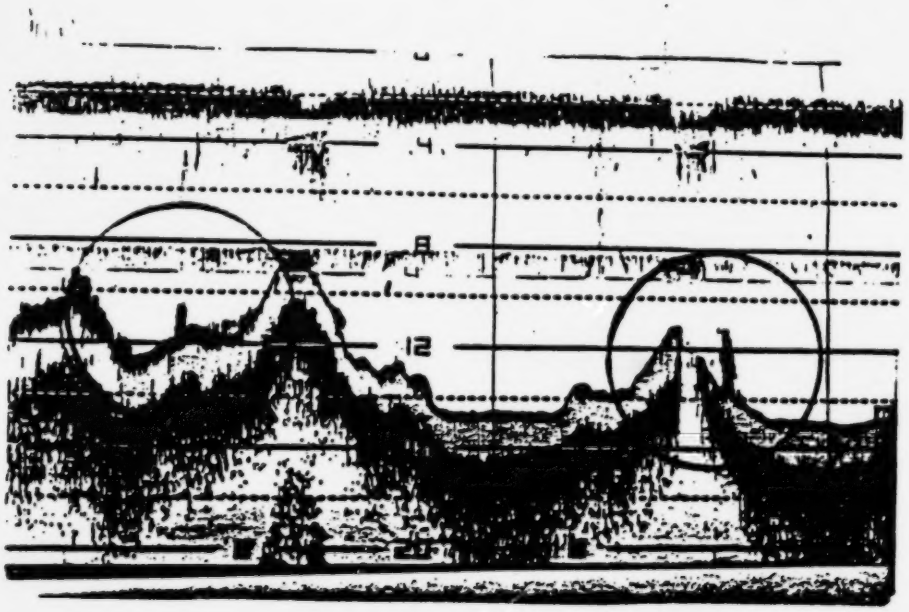


Figure 4. X-15 Graph Example.

Left - Wooden basket trap 1-ft high.

(depth range 0 to 20 ft)

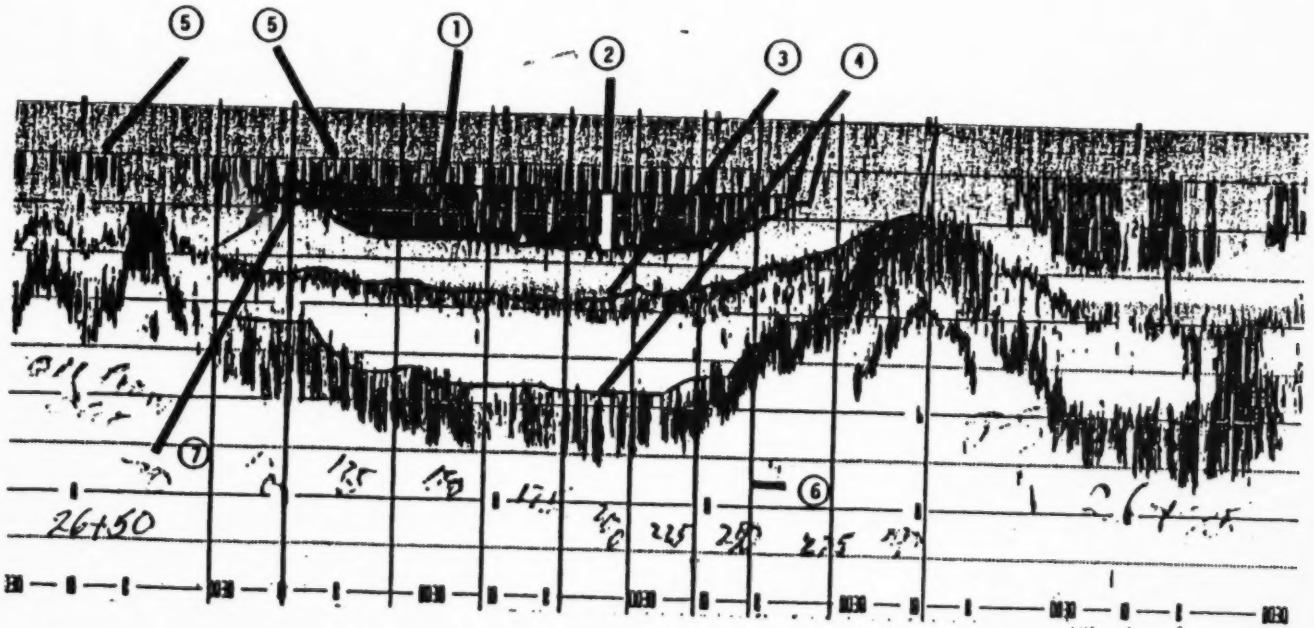
Right - Hoop net 3-ft tall.

locating objects. Figure 3 shows a drowning victim, marked B, next to a 55-gal (200-L) drum, marked A. (The left side of Figure 3 is mapped on a 20 to 40 ft (6 to 13 m) range.) Note the unidentified object to the far left, marked "C". The same object("C" on the left of the Figure) is mapped as "D" (right side) on the 30-40 ft (11-13 m) range with twice the resolution. Figure 4 is a graph from the use of the X-15 in locating illegal fish traps. The circled object on the left is a 2 ft (0.6 m) wooden basket and the object on the right is a 3-ft (1-m) high hoop net. The X-15 system obviously has considerable utility in the location of containers of hazarous materials lost overboard. The X-15-A version to be marketed in September, 1983, has several additional features; these offer nothing to the use in searching for pollutant pools and, in fact, are designed to eliminate the very signals required. A 1984 version, the X-15-B, will have improved depth resolution and can be set to display only the bottom 1 ft (30 cm) of the water column. This feature will be of great value during the mapping phase of a response.

CREOSOTE POND MAPPING

A long-standing operation had generated a 360-by-300 ft (110-by-90 m) pond that was badly contaminated with creosote. Creosote is an oily liquid with a nominal specific gravity of 1.07. The Lowrance X-15 graph recorder was deployed in an effort to determine the extent of contamination. A 100,000-gal (375,000 L) pool of creosote was found suspended 2 ft (60 cm) below the water surface and 1.2 ft (35 cm) above the bottom. A layer of material suspected of being creosote-contaminated sediment followed the bottom contour. Figure 5 shows the recording from one traverse of the pond. The creosote pool and contaminated bottom layer are captioned.

The small size of the pond allowed the use of a simple method of micro-navigation. Survey lines were run on two (opposite) sides of the pool with stakes placed 25 ft (7.5 m) apart along the lines. A rope having a knot every 25 ft (7.5 m) was attached to the study boat and was dragged forth and back over the pond between the stakes. Shore operators notified the X-15 operator of the passage of each knot and he marked the chart accordingly. Data reduction was made at 5-ft (1.6-m) intervals by interpolating between the 25-ft (7.5-m) markers on the chart. Where the graph indicated the presence of the pool, an oar dipped 3 ft (1 m) below the water surface brought up creosote.



① Top of creosote pool

② Bottom of creosote pool

③ Top of sludge (or soft bottom)

④ Top of hard sand bottom

⑤ Instrumental artifact

⑥ Survey grid markings

⑦ An oar dipped below the surface brought up dark oily liquid

Figure 5. Creosote Pond Study

The floating creosote lens was not visible from the surface of the pond.

Similar testing with the boat oar in a non-indicating area showed no subsurface creosote. The presence of creosote in the muck layer was not verified. The characterization of the pond required about 5 hours of mapping time in the boat.

CONCLUSIONS

At least one portable, commercial device is now available for operation from a boat to locate and to determine the thickness of pools of insoluble sunken hazardous substances in waterbodies. Containers can also be located. The coordinates of the boat position must be determined when the data are to be properly transcribed to a map. Both laboratory prototypes and a commercial instrument have been evaluated in small scale tests and in the field. At actual sites, spilled ethylene dichloride and creosote have been mapped at thicknesses greater than 1 cm and at depths of 10 meters. When the transmitter/detector is suspended far below the boat, the depth limit can be increased significantly. The water surface need not be calm; however, heavy seas or fast currents do impede data acquisition. Vertical profiling of the spilled hazardous substance is more precise than is the determination of the coordinates of the boat position.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance provided by Larry Marks and Dr. Milton Kirsch of Rockwell International.